Loop-Controlled Chlorine Production for Disinfection of Pool-Water using Boron-Doped Diamond Electrodes

W. Haenni, A. Perret, L. Pupunat, J.Gobet, Ph. Rychen,
Swiss Center of Electronic and Microtechnology SA, (CSEM), CH-2007 Neuchâtel, Switzerland
werner.haenni@csem.ch

Ch. Comninellis, B. Correa,
Institute of Chemical Engineering, Swiss Federal Institute of Technology-Lausanne (EPFL), CH-1015 Lausanne, Switzerland

For several years, electrochemical properties of synthetic, polycrystalline, in-situ boron and boron/nitrogen co-doped diamond films have been studied. They are of particular interest as diamond displays the widest known electrochemical window, associated with a very small background current in cyclic voltammetry, allowing a variety of electrochemical reactions and electroanalysis. The chemical inertness of such polycrystalline diamond has been proved especially in very oxidizing media without affecting the diamond electrodes. [1]

Diamond coatings of 0.1 to 1 µm thickness on 1 mΩcm p-Si plates, Nb- and most recently also Ti- and Zr-sheets (DiaChem®-Electrodes)[2] mounted in a DiaCell® (Fig. 1) have shown outstanding electrochemical properties in the oxidation of organic and inorganic compounds. This reactivity can be associated with the production of hydroxyl radicals, which may also be responsible for the production of chlorine, ozone, persulfate and hydrogen peroxide in natural mineralized water.

In fact, in a simulated natural water ($Ca_2H_2CO_3$, $NaHCO_3$, NaCl, pH adjusted with H_2SO_4 to pH 7.2) $2x10^4$ Escheria Coli/cm^3 have been inactivated by electrochemical treatment in 1 m^3 with 0.13 g/h of chlorine production within 480 min. The resulting total chlorine concentration at the end of the treatment was 0.14 ppm. Whereas the same quantities of Escheria Coli ($2x10^4/cm^3$) could be diminished in 480 min. only by one order of magnitude by addition of a corresponding amount of sodium hypochloride. The resulting free chlorine concentration was 0.4 ppm.

In the same simulated natural water, but containing 0.2 ppm of free chlorine, either electrochemically produced or by adding of NaOCl a $1x10^6$ E. Coli/cm^3 are inactivated in 20 min. respectively in 60 min (Fig. 2). Therefore, it can be shown that the electrochemical disinfection with the help of diamond electrodes is more efficient even without adding of chemical agents.

The chlorine concentration in the water was measured by means of a new type of a direct measuring (no membrane) and highly selective sensor in the range of 0.02 to 10 ppm. A similar system is under test for ozone detection for the range of 0.002 to 1 ppm. In a combination with a DiaCell® (described above) and the direct measuring chlorine sensor the chlorine production for disinfection of pool-water can be easily loop-controlled at a level of 0.2 to 0.5 ppm assisted by a microprocessor.

To sum up, it is shown that an electrochemical loop controlled production of oxidizing agent such as chlorine and ozone, based on diamond electrodes, is a highly efficient method for the disinfection of water.

References:

1. D. Gandini, E. Mahé, P.A. Michaud, W. Haenni, A. Perret, C. Comninellis, J. applied el. chemistry 30, (2000) 1345
2. M. Fryda, A. Dietz, D. Herrmann, A. Hampel, L. Schäfer, C.-P. Klages, A. Perret, W. Haenni, C. Comninellis, D. Gandini, Electrochemical Proceedings volume 99-32, (2000) 473

Fig.1 DiaCell® equipped with circular monopolar and bipolar diamond electrodes of 100 mm diameter used for the loop-controlled 0.2 to 0.4 ppm level chlorine production for disinfection of pool-water.

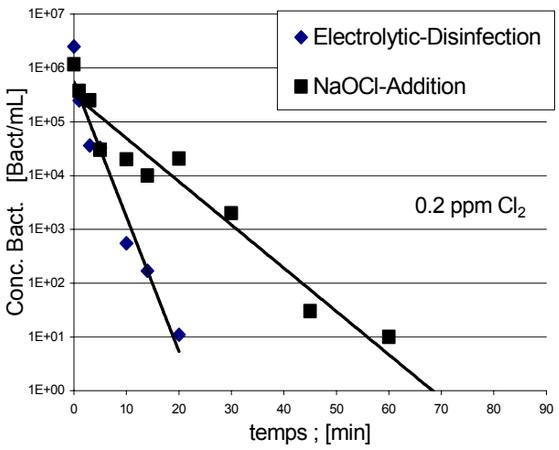

Fig. 2. Comparison of the effect on E. Coli of electro-chemically produced or directly added hypo chlorite (NaOCl) solution at a concentration of 0.2 ppm active chlorine